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BACTERIAL CONTAMINATION OF INDOOR AIR AS A FUNCTION OF AIR EXCHANGE

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16. Abstract

Airborne bacteria counts were taken in operating rooms with natural ventilation and with ventilation systems producing hourly air exchange rates of 12× and 20×; the average counts were about 700, 300 and 60 bacteria/m^3, respectively. An operating cubicle with a low-turbulence displacement system produced a zero bacteria count. Tests in a climate chamber with a variable air exchange rate showed an appreciable reduction in bacteria count resulting when air exchange rate was increased to 25 h^{-1}.

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BACTERIAL CONTAMINATION OF INDOOR AIR AS A FUNCTION OF AIR EXCHANGE

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Problem

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The hourly rate of air exchange is one of the decisive factors in the effectiveness of an air-conditioning system, particularly when it is necessary to keep the airborne bacteria level in an occupied area as low as possible. These studies were designed to determine the effect of the rate of air exchange on the level of bacteria in the air. Airborne bacteria counts were taken for this purpose in four operating rooms with different ventilating systems.

Measurements Made in Operating Rooms

We used Casella slit samplers to detect airborne bacteria. The medium was blood agar, which was incubated for 48 hours at 37ºC. Sampling was done at a distance of 1 to 2 m from the operating area.

Figure 1 provides an overview of the results from the four operating rooms. Averages are given from comparable series of measurements. Overall, airborne bacteria counts decreased stepwise with increasing air exchange rate, both before and during operations.

In operating rooms both with natural ventilation and with conventional ventilation (12× and 20× hourly air exchange rate), high peaks in the airborne bacteria level occurred during intense activity (preparation for operation, taking x-rays). No bacteria could be detected in the operating cubicle

*Numbers in the margin indicate pagination in the foreign text.

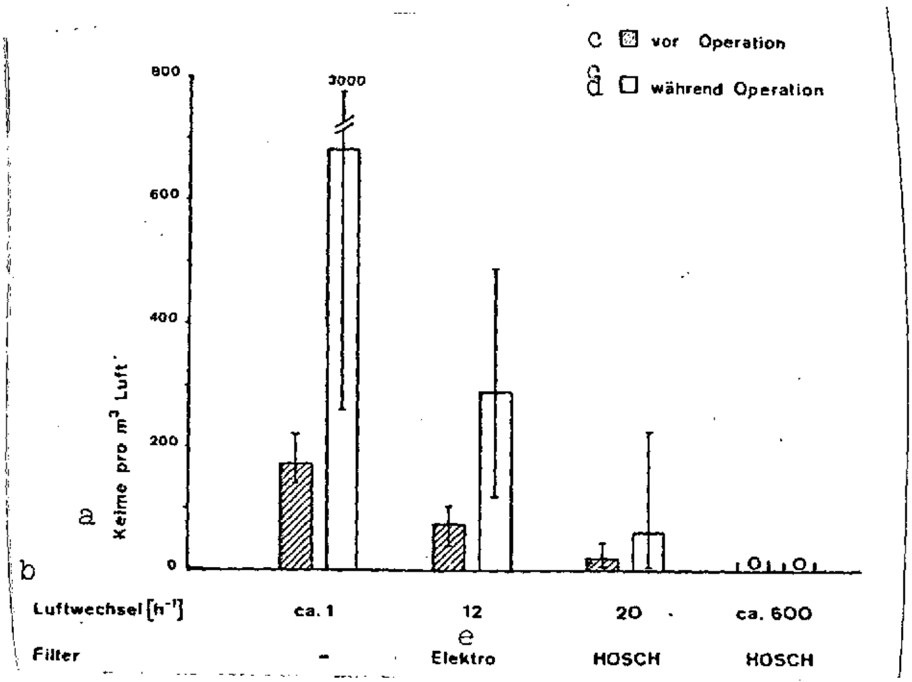

Fig. 1. Airborne bacteria counts in four operating rooms with different ventilating systems. Sampling: slit samplers (150 ℓ air/5 min); medium: blood agar (37°C/48 h).

Key: a. Bacteria per m^3 air
b. Air exchange rate
c. Before operation
d. During operation
e. Electrostatic

air with low-turbulence displacement flow at an exchange rate factor of about 600.

In interpreting these results, it should be noted that other factors in addition to air exchange rate varied (filter quality, operating procedure, personnel) which can have an effect on airborne bacteria counts.

For this reason, we performed an additional study in a climate chamber in which air exchange can be varied systematically during standardized activity.

Measurements Made in a Climate Chamber /565

Figure 2 shows a schematic of the climate chamber (4 × 3 ××2.5 m; 30 m^3), which is entered through an airlock (1.5 × 1 × 2.5 m; 3.75 m^3). The ventilating system permits the air exchange rate to be varied systematically between zero and 25 h^{-1}. Inlet air is purified with a preliminary filter, fine dust filter, activated charcoal filter and Hosch filter. Three inlet and three outlet louvers are installed in the ceiling so that a roller-like ventilation pattern occurs in the area.

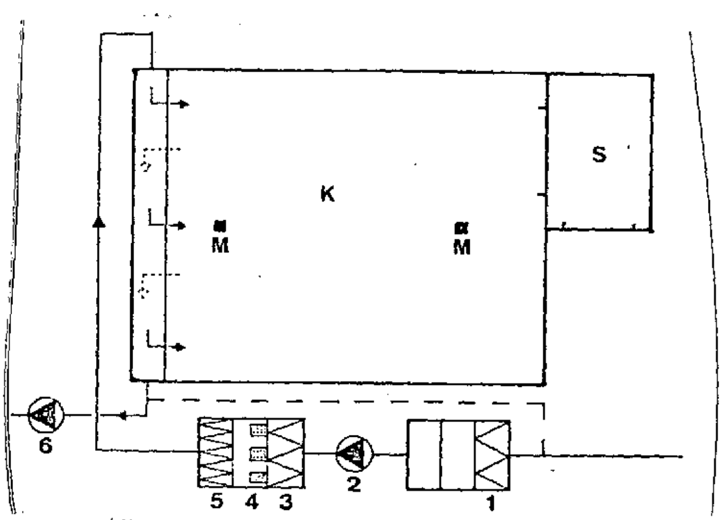

Fig. 2. Schematic of climate chamber (4 × 3 × 2.5 m). K = test chamber, S = air lock, M = measurement point; 1. preliminary filter; 2. inlet fan, 3. fine dust filter, 4. activated charcoal filter, 5. Hosch filter, 6. outlet fan.

The studies were performed at air exchange rates of 0.3, 5, 10, 20 and 25 h^{-1}. Three measurement periods of 60 min each were taken at each air exchange rate. During each measurement period, ten successive samples each were taken with two Casella slit samplers (5 min/150 ℓ air). During this time, a test subject performed a standardized activity (remove laboratory smock, shake out, put smock on again).

The results of the studies performed in the climate chamber are plotted in Fig. 3: The curve is a mean from three repetitions with 20 individual values each. A stepwise reduction in airborne bacteria count was obtained with increasing air exchange rate: When air exchange rate was increased from 0.3 to 10 h^{-1}, a reduction in airborne bacteria count by about 150 bacteria/m^3 resulted, but an increase from 10 to 25 h^{-1} only produced a drop of about 60 bacteria/m^3. It is also conspicuous that at the low air exchange rates (0.3 and 5 h^{-1}), considerably higher dispersion levels occur than at /567
the higher air exchange rates; thus the dissemination of bacteria within the area can be handled better and brought under control at a high air exchange rate.

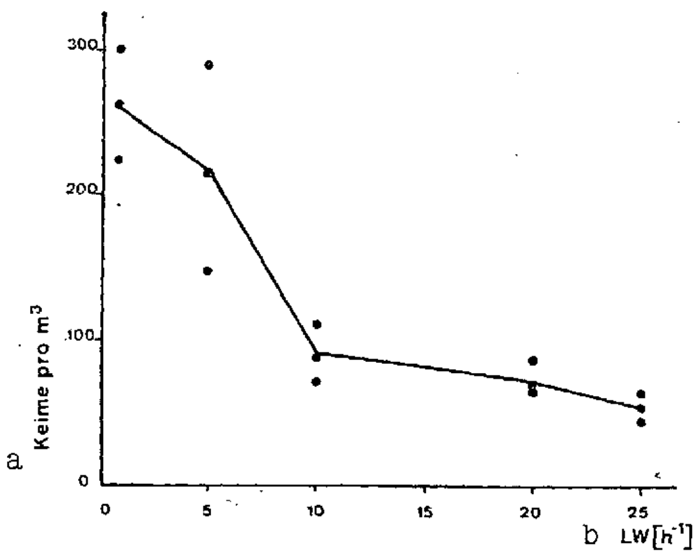

Fig. 3. Effect of air exchange on airborne bacteria count (climate chamber). Sampling: slit sampler (150 ℓ air/5 min); medium: "Difco" plate-count agar + 0.2°/oo actidione (37°C/48 h); one test subject, standardized activity.

Key: a. Bacteria
b. Air exchange rate

Summary

Airborne bacteria counts taken in four operating rooms with different ventilating systems showed that for conventional ventilation, an increase in air exchange to 20 h^{-1} produces a distinct reduction in airborne bacteria count: During operations, an average of about 700 bacteria//m^3 was found in an operating room with natural ventilation,

about 300 bacteria/m^3 in an operating room with an hourly air exchange factor of 12, and about 60 bacteria/m^3 in an operating room with an hourly air exchange factor of 20. No bacteria were detectable in an operating cubicle with low-turbulence displacement flow (about 600× air exchange).

An appreciable reduction in the airborne bacteriallevel was obtained by increasing air exchange to 25 h^{-1} in a climate chamber with a variable rate of exchange.